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Pneumothorax in patients with COVID-19 pneumonia in the intensive care unit: an indicator of poor prognosis

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ABSTRACT

Aims: The objective of this study was to investigate whether the incidence and development of pneumothorax in patients hospitalized in the intensive care unit (ICU) with coronavirus disease 2019 (COVID-19) pneumonia is associated with patient prognosis.

Methods: This retrospective, cohort, descriptive study was initiated following approval from the ethics committee. The study was conducted on patients with confirmed COVID-19 pneumonia admitted to the tertiary ICU between March 2020 and March 2022. Data were collected from the patient registry system and ICU files. The patients were divided into two groups: those who developed pneumothorax and those who did not. The factors associated with mortality in the ICU were evaluated by univariate analysis and multiple logistic regression analysis.

Results: The study included a total of 397 patients with confirmed cases of COVID-19 infection and pneumonia who were admitted to the ICU between March 2020 and March 2022. The mean age of the patients was 62±15 years. Of the patients, 56.1% were male. Pneumothorax was identified in 6.8% of patients. In addition to pneumothorax, six patients (1.5%) exhibited pneumomediastinum. The mortality rate was observed to be 40.5% among the total patient population. The mortality rate was 81.5% in the group with pneumothorax and 37.6% in the group without pneumothorax. The median time to mortality was 6 days (range 1–29 days) following the diagnosis of pneumothorax. Pneumothorax alone increased the likelihood of mortality in the ICU sevenfold (OR 7.3, 95% CI=2.70–19.75) and twofold when other variables were taken into account (OR 2, 95% CI=0.57-6.99).

Conclusion: Pneumothorax is a common and fatal complication affecting mortality in patients with COVID-19 pneumonia in the ICU, despite the use of protective ventilation strategies. Particular caution should be exercised in patients receiving respiratory support in the ICU and in patients with a severe inflammatory response.

Keywords: Pneumothorax, pneumomediastinum, intensive care unit, prognosis, COVID-19

INTRODUCTION

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus was initially identified in Wuhan, China, in December 2019.[1] On March 11, 2020, the World Health Organization (WHO) declared a global pandemic, a designation that remained in effect in our country until July 1, 2021. During this period, there was an increase in intensive care unit (ICU) hospitalization and mortality rates. A review of the extant literature reveals that the mortality rates reported for patients who were hospitalized in ICUs within our country exhibit variability, with rates ranging from 47% to 66% being documented.[2-4] The 2019 novel coronavirus disease (COVID-19), which continues to manifest in different variants, remains a significant public health concern.[5] The most commonly utilized diagnostic techniques for the identification of SARS-CoV-2 infection are reverse transcriptase-polymerase chain reaction (RT-PCR) testing and thorax computed tomography (CT) scanning.[6] In more than 70% of cases of patients with a positive RT-PCR test result for SARS-CoV-2, there are specific characteristics observed on thorax CT scans. These include ground-glass opacities, vascular enlargement, bilateral abnormalities, lower lobe and posterior involvement.[7] However, less common radiological findings have also been observed in patients with confirmed SARS-CoV-2 infection, including pneumothorax, bullae, pleural effusion, lymphadenopathy, central lesion distribution, and pericardial effusion.[8,9] COVID-19 differs from other

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causes of acute respiratory distress syndrome (ARDS) due to its potential to induce vascular and parenchymal damage through inflammatory cascades.[10,11] Consequently, it is more probable that the development of pneumothorax and other associated complications will be observed.

In the lung parenchyma, COVID-19 pneumonia can produce cystic lesions that may disappear or develop into larger blisters.[12,13] As a result, patients may be at risk of rupture, which can subsequently lead to spontaneous pneumothorax or mediastinal and subcutaneous emphysema.[14] Primary spontaneous pneumothorax has no known etiology, but secondary spontaneous pneumothorax results from an underlying lung pathology.[15] It can occur in 1% of hospitalized patients,[16] 3% of patients hospitalized for pneumonia,[17] 6% of mechanically ventilated patients,[18] and 1% of deceased patients.[19] Due to the poor understanding of lung histology in these patients, it is unknown how effectively damaged lung tissue will heal and re-expand on its own in COVID-19 individuals.[20] Patients with neutrophilia and a prolonged clinical course are more likely to experience diffuse lung injury and pneumothorax.[21] Similarly, pneumothorax is considered a poor prognostic feature of Middle East Respiratory syndrome (MERS) coronavirus associated infection.[22] It has been suggested that rapid diagnosis and management of pneumothorax may reduce morbidity and mortality in COVID-19 patients.[21,23] However, clinical data are lacking in this regard. In addition, its incidence in ICU patients is not known exactly.

The objective of this study was to investigate the incidence of pneumothorax in patients hospitalized with COVID-19 pneumonia in the ICU and to determine whether its development is associated with a poor prognosis. The present study was designed in accordance with the hypothesis that the development of pneumothorax in patients with SARS-CoV-2 infection and pneumonia requiring ICU admission is associated with an adverse prognosis. The objective was to ascertain whether the mortality rate among patients with SARS-CoV-2 infection and pneumonia requiring ICU admission, with or without the development of pneumothorax, differs from that observed among patients without pneumothorax.

METHODS

Study Design and Patients

This retrospective cohort descriptive study was initiated following approval from the Clinical Researches Ethics Committee of Yıldırım Beyazıt University, Yenimahalle Training and Research Hospital (Date: 13/09/2023, Decision No: E-2023-43). All procedures were conducted in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national) and the Declaration of Helsinki, as revised in 2013. The present study was conducted through a review of patient registries and ICU follow-up data on patients with confirmed COVID-19 pneumonia who were admitted to tertiary ICU at two medical centers between March 2020 and March 2022. Lung-protective ventilation strategies were a standard procedure in all ICUs.

The inclusion criteria were as follows: (1) admission to the ICU between March 2020 and 2022, (2) confirmation of SARS-CoV-2 infection via positive PCR test results on nasopharyngeal swabs or respiratory tract secretions, or via the presence of SARS-CoV-2 infection on thorax CT scans, and (3) presence of diagnosed lung involvement and pneumonia. Patients with incomplete or missing data in the registry system and ICU files, as well as those with duplicate hospitalizations (in which the data from the first hospitalization were evaluated), were excluded from the study.

Patients with a confirmed diagnosis of SARS-CoV-2 infection were identified through the presence of SARS-CoV-2 ribonucleic acid (RNA) in a nasopharyngeal swab or respiratory secretion, or through an official diagnosis in the hospital registration system with a documented involvement of the virus in the patient's thorax CT report. Pneumothorax detection was defined as patients with a diagnosis of pneumothorax in the hospital information registry system whose diagnosis was confirmed by chest radiography. The following data were recorded from the hospital information system: demographic data, Acute Physiologic Assessment and Chronic Health Evaluation (APACHE) II scores (at the 24th hour of admission), laboratory parameters (white blood cell count (WBC), neutrophil count, C-reactive protein (CRP), hemogram, D-dimer), and body-mass index (BMI). Furthermore, data regarding the administration of respiratory support devices, the duration of such support, the presence of intubation, the development of pneumothorax, the side of the lung affected by pneumothorax, ICU mortality, how many days after the pneumothorax the mortality occurred and ICU length of stay were obtained from ICU records. The highest laboratory parameter values during the ICU stay were included in the study. The data of patients diagnosed with COVID-19 pneumonia in the ICU with and without pneumothorax were compared. The effect of pneumothorax on estimated mortality was evaluated.

Outcome

The primary outcome measure of the study was the ICU mortality rate in patients admitted to the ICU with COVID-19 pneumonia with and without pneumothorax. Additional outcome measures included the factors associated with mortality in patients with COVID-19 pneumonia, the contribution of the pneumothorax factor to mortality, and descriptive characteristics of patients with pneumothorax.

Statistical Analysis

The data were subjected to statistical analysis using the statistical package for the social sciences (SPSS) 24.0 software (SPSS Inc., Chicago, IL, USA). Descriptive statistics were expressed as the number (n) of cases, percentage (%), mean±standard deviation ($\bar{x}$±SD), or median (Q-Q3), minimum (min) value, and maximum (max) value. Categorical and demographic data were tabulated as number of cases and percentage. A Chi-square test was employed to ascertain whether two rates exhibited a statistically significant discrepancy. The distribution of the obtained data was evaluated using the Shapiro-Wilk test. In accordance with the distribution outcomes of the numerical data, a comparison of

paired groups was conducted using Student's t-test and Mann-Whitney U test. The comparison of categorical data between groups was conducted using either the Pearson Chi-Square test or the Fisher exact test. The relative odds ratio (OR) was calculated using the ICU mortality values observed in patients with and without pneumothorax. A p-value of less than 0.05 was considered statistically significant.

A logistic regression analysis was conducted using the variables that were statistically significant in terms of ICU mortality in univariate analysis, as well as variables that were not statistically significant but had a p-value less than 0.2. Eight variables were identified as potentially suitable for inclusion in the multivariate logistic regression model. To ascertain the likelihood of multicollinearity, all variables were subjected to correlation analysis, variance inflation factor assessment, and tolerance value analysis. The WBC value was excluded from the model due to its high correlation with the neutrophil value. The residue and Cook distance values were subjected to rigorous control. No variables were excluded from the data set. The APACHE II score was excluded from the model due to its minimal contribution (likelihood ratio (LR) test X^2 values 0.58). Ultimately, six variables were incorporated into the model: age, neutrophil count, CRP value, male gender, D-dimer value, and the presence of pneumothorax. The omnibus test yielded a p-value of less than 0.001, confirming the overall fit of the model. The model demonstrated an accuracy power of 49% (Nagelkerke R^2 = 0.4880).

RESULTS

The data of 421 patients who met the study's inclusion criteria during the specified period were evaluated. However, 24 patients were excluded from the study due to incomplete data and duplicate hospitalizations, resulting in a final sample of 397 patients who were hospitalized in ICU between March 2020 and March 2022 and diagnosed with COVID-19 pneumonia. The mean age of the patients was 62±15 years. Of the total number of patients, 223 (56.1%) were male. Pneumothorax was identified in 6.8% (n=27) of the patients. Table 1 presents the demographic and clinical characteristics of patients with and without pneumothorax.

The APACHE II score, WBC count, neutrophil count, CRP value, and D-dimer value were found to be statistically higher in patients with pneumothorax compared to those without (p<.001). At the time of pneumothorax diagnosis, 5 patients (18.5%) were on non-invasive mechanical ventilation, 9 patients (33.3%) were on invasive mechanical ventilation, and 13 patients (48.2%) were on respiratory support with nasal high-flow oxygen therapy. Pneumothorax was identified on the right side in 13 patients (48%), on the left side in 7 patients (26%), and in both lungs in 7 patients (26%). Chest tubes were placed in all patients. In addition, 6 patients (22.2%) exhibited concomitant pneumomediastinum. Mortality occurred on median day 6 (min=1, max=29) after the diagnosis of pneumothorax.

The mortality rate was 40.5% (n=161) among the total patient population. The mortality rate was 81.5% (n=22) in the group with pneumothorax and 37.6% (n=139) in the group without pneumothorax. This difference between the groups was statistically significant and higher in the pneumothorax group (p<.001). Table 2 presents the demographic and clinical characteristics of patients with and without mortality.

The results of the logistic regression analysis for ICU mortality are presented in Table 3. Univariate logistic regression showed a sevenfold increase in ICU mortality with the occurrence of pneumothorax in COVID-19 pneumonia in the ICU (OR 7.3, 95% CI=2.70-19.75). This association was twofold in multivariable adjustment (OR 2, 95% CI=0.57-6.99). In the multivariate analysis, increasing age, increasing neutrophil count, high CRP value, and male gender were identified as independent variables significantly associated with increased mortality from COVID -19 pneumonia in the ICU. The logistic regression analysis demonstrated that age was the most influential factor in the model, with a LR test X2 value of 48.9 and a p-value of <.001. The model's performance in terms of mortality was determined to be 68.3% sensitivity and 84.7% specificity, with an accuracy of 78% and an area under the receiver operating characteristic curve (AUC) of 0.86 (Figure).

Table 1. Demographic and clinical characteristics of patients with and without pneumothorax

		Pneumothorax, No, (n=370)	Pneumothorax, Yes, (n=27)	p-value
Age, year, median (Q1-Q3)		63 (53-74)	65 (57.5-74)	0.459
Gender, n (%)	Female	165 (94.8%)	9 (5.2%)	0.255
	Male	205 (91.9%)	18 (8.1%)	
BMI, kg/m², mean±SD		27.04±3.86	26.45±3.26	0.367
APACHE II score, median (Q1-Q3)		20 (15-24)	25 (20.5- 29)	**<.001**
WBC /µL, median (Q1-Q3)		9460 (6198-13300)	20750 (15040-27995)	**<.001**
Neutrophil /µL, median (Q1-Q3)		8195 (4253-11928)	18230 (13515-24680)	**<.001**
CRP mg/L, median (Q1-Q3)		81.36 (19.70-164.3)	189.6 (149.1-277.5)	**<.001**
D-dimer mg/L, median (Q1-Q3)		1.12 (0.54-2.45)	6.48 (3.73-12.45)	**<.001**
ICU length of stay, median (Q1-Q3)		9 (5-19)	10 (4.5-23)	0.938
ICU mortality	No, n (%)	231 (97.9%)	5 (2.1%)	**<.001**
	Yes, n (%)	139 (86.3%)	22 (13.7%)	

Continuous variables are expressed as either the mean±standard deviation (SD) or median (Q1-Q3) and categorical variables are expressed as either frequency (percentage). Continuous variables were compared with Student-t test or Mann-Whitney U test, and categorical variables were compared using Pearson'schi-square test or fisher exact test.
APACHE II: Acute physiologic assessment and chronic health evaluation, BMI: Body-mass index, CRP: C-reactive protein, ICU: Intensive care unit, SD: Standart deviation, WBC: White blood cell

Table 2. Demographic and clinical characteristics of patients with and without mortality

		Mortality, No, (n=236)	Mortality, Yes, (n=161)	p-value
Age, year, median (Q1-Q3)		58 (47-67)	70 (63-78)	<.001
Gender, n (%)	Female	116 (66.7%)	58 (33.3%)	0.010
	Male	120 (53.8%)	103 (46.2%)	
BMI, kg/m², mean±SD		23.9±5.05	28.06±6.56	0.198
APACHE II skor, median (Q1-Q3)		19.5 (15-24)	20 (17-25)	**0.002**
WBC /µL, median (Q1-Q3)		7870 (5520-11493)	13470 (9230-18010)	**<.001**
Neutrophil /µL, median (Q1-Q3)		6150 (3365-9513)	12300 (8570-16920)	**<.001**
CRP mg/L, median (Q1-Q3)		63.29 (15.23-131.7)	149 (68.69-223.4)	**<.001**
D-dimer mg/L, median (Q1-Q3)		0.7 (0.41-1.7)	2.2 (1.14-6.46)	**<.001**
Pneumothorax	No, n (%)	231 (62.4%)	139 (37.6%)	**<.001**
	Yes, n (%)	5 (18.5%)	22 (81.5%)	

Continuous variables are expressed as either the mean±standard deviation (SD) or median (interquartile range) and categorical variables are expressed as either frequency (percentage). Continuous variables were compared with Student-t test or Mann-Whitney U test, and categorical variables were compared using Pearson'schi-square test or fisher exact test.
APACHE II: Acute physiologic assessment and chronic health evaluation, BMI: Body-mass index, CRP: C-reactive protein, SD: Standart deviation, WBC: White blood cell

Table 3. Univariate and multivariate logistic regression modeling for intensive care mortality in COVID-19 patients

Prediction variable	Unadjusted			Adjusted		
	OR	95% CI	p-value	OR	95% CI	p-value
Age, year	1.072	1.052-1.091	<.001	1.072	1.048-1.095	<.001
Neutrophil, /µL	1.0002	1.0001-1.0003	<.001	1	1.0001-1.00019	<.001
CRP, mg/L	1.008	1.006-1.0109	0,001	1.004	1.0013-1.0072	0.005
Gender, male	1.7167	1.1385-2.5885	0.010	2.133	1.2382-3.6758	0.006
D-dimer, mg/L	1.1091	1.0574-1.1633	<.001	1.029	0.9912-1.0684	0.134
Pneumothorax, Yes	7.3	2.7074-19.7492	<.001	2.008	0.5769-6.9925	0.273

CRP: C-reactive protein, OR: Odds ratio, CI: 95% confidence interval

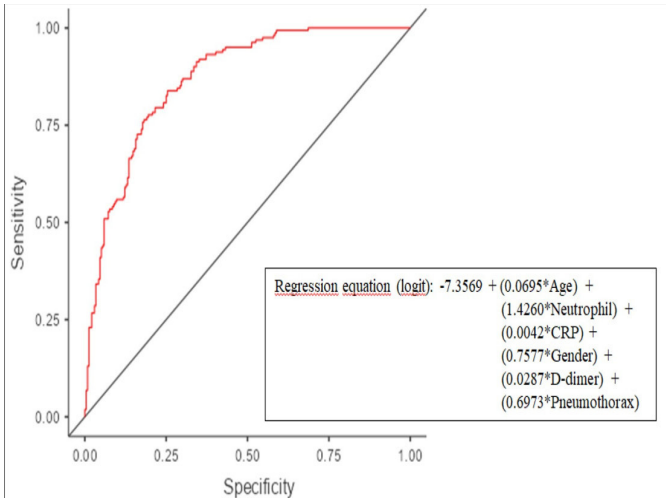

Figure. Area under the receiver operating characteristic curve for intensive care mortality in COVID-19 pneumonia

DISCUSSION

The objective of this study was to examine the influence of pneumothorax on mortality rates among patients admitted to the ICU with COVID-19 pneumonia. Pneumothorax was identified in 6.8% of patients hospitalized in the ICU with COVID-19 pneumonia. Pneumothorax was identified in the right lung in 48% of cases, in the left lung in 26% of cases, and in both lungs in 26% of cases. At the time of diagnosis of pneumothorax, all patients were receiving respiratory support. The mortality rate among patients with pneumothorax in the ICU was 81.5%. The median time to mortality was six days after diagnosis. Our findings indicate that the development of pneumothorax in the ICU in patients with COVID-19 pneumonia was associated with a seven-fold increase in mortality when considered as a single factor and a two-fold increase when other factors were taken into account. Furthermore, age, neutrophil count, CRP value, and male gender were identified as independent variables associated with mortality in patients with COVID-19 pneumonia. The most significant independent variable affecting mortality was the patient's age.

Pneumothorax is defined as the accumulation of air between the visceral and parietal pleurae, which surround the lungs. Secondary spontaneous pneumothorax is a consequence of underlying lung disease, whereas primary spontaneous pneumothorax can occur without any triggering event. The precise etiology of the injury remains uncertain. However, it is plausible that infection-related alveolar damage and alveolar wall rupture resulting from elevated pressure caused by intense coughing in response to the virus may be the primary causes.[24] Furthermore, an inflammatory response during lung infections has the potential to contribute to the development of secondary spontaneous pneumothorax. Some studies have indicated that inflammatory exudates may be involved in the pathogenesis of pneumothorax, even in the absence of mechanical ventilation.[11,25] Pneumothorax has been identified as a potential, albeit uncommon, consequence of SARS-CoV-2 infection since the initial reports of cases emerged. The autopsy studies of patients with COVID-19 have revealed that the most prevalent pulmonary pathological findings were diffuse alveolar damage, comparable to that observed in patients with severe ARDS, and the formation of pneumothorax. These findings lend support to the hypothesis that pulmonary parenchymal damage may be a consequence of the disease.[26,27] The incidence of pneumothorax exhibits

considerable variability in the literature, particularly in the context of ARDS patients, with reported rates ranging from 1.7% to 10%.[28,29] In their study of patients with COVID-19, Wang et al.[23] observed an incidence of pneumothorax of 10% in patients without mechanical ventilation and 24% in those who required it. Yang X et al.[30] observed a rate of 2.7% in patients with COVID-19 who were receiving mechanical ventilation, whereas Sihoe et al.[28] reported a rate of 1.7% in patients with severe acute respiratory syndrome (SARS) who had ARDS. In our study, we observed a pneumothorax rate of 6.8% in patients hospitalized in the ICU with COVID-19 pneumonia. Although this rate is consistent with the literature and relatively high, it is an expected finding when considering that the majority of studies in the literature were conducted with ward patients and that our patient group consisted of high-risk patients on respiratory support in the ICU. It is of the utmost importance to implement effective prevention, immediate recognition, and treatment strategies for pneumothorax in order to minimize mortality rates among patients with lung infections and predominant inflammatory processes, such as those observed in patients with SARS-CoV-2 infection who are hospitalized in the ICU and receive respiratory support.

In the existing literature, cases of pneumothorax and pneumomediastinum induced by SARS-CoV-2 are frequently reported together. However, it should be noted that these studies are all case series.[24,31] The occurrence of spontaneous pneumothorax may be classified as primary or secondary, contingent upon the presence or absence of an underlying lung disease.[32] In contrast, the presence of pneumomediastinum may be classified as primary if the underlying cause is idiopathic or secondary if it responds to a spontaneous, traumatic, or iatrogenic etiology.[33] The coexistence and incidence of pneumothorax and pneumomediastinum remain unclear. However, it is evident that their association has a detrimental impact on prognosis.[31] Ulutas et al.[21] identified the presence of pneumothorax in eleven patients diagnosed with SARS-CoV-2 infection, yet no instances of pneumomediastinum observed. In our study, the occurrence of pneumothorax was observed in conjunction with pneumomediastinum in six of the 27 patients (22.2%). In comparison to the overall study population, this rate was 1.5%. The prognosis for these patients was poor, and mortality was observed in the ICU. Our findings indicate that, although the frequency of this association is low, it should be considered as a potential diagnosis in critically ill patients hospitalized in the ICU.

Previously, it was postulated that the presence of pneumothorax was a significant prognostic factor in patients infected with the novel coronavirus.[22,34] However, the literature on the subject of COVID-19 is limited to case series. Concurrently, the treatment of pneumothorax in conjunction with SARS-CoV-2 infection, which can result in severe manifestations, may potentially lead to an increased incidence of comorbidities and complications. In particular, the insertion of a chest drain to treat pneumothorax can be considered an aerosol-generating technique. Furthermore, recent postmortem findings have revealed the presence of RNA from the SARS-CoV-2 in pleural fluid.[35] In this regard, the management of pneumothorax represents a significant challenge. In a retrospective study by Ershadi et al.[36] of patients with COVID-19 and pneumothorax admitted to the ward, the 50-day mortality rate was 52.2%. An analysis of the data regarding the COVID-19 in our nation reveals that the mortality rate among patients admitted to the ICU with the disease ranges from 47% to 66%.[2-4] Satici et al.[37] reported a 30-day mortality rate of 60% in patients hospitalized in the ICU in their study on patients diagnosed with pneumonia caused by the COVID-19. This mortality rate was observed to be higher in the geriatric age group and in patients with comorbidities.[2] In our study, which was conducted on patients diagnosed with COVID-19 pneumonia in the ICU, the mortality rate was 81.5% in patients who developed pneumothorax. In the univariate analysis, it was determined that the presence of pneumothorax was associated with a sevenfold increase in mortality, which was reduced to twofold when other variables were taken into account. In light of these findings, the presence of pneumothorax in conjunction with the inflammatory process is associated with a poor prognosis in the ICU.

The use of non-invasive and invasive mechanical ventilation in the treatment of patients with COVID-19 has been associated with an increased risk of developing pneumothorax.[38] In a series of eleven cases, Ulutas et al.[21] reported the development of spontaneous pneumothorax in patients with COVID-19. While the provision of respiratory support increases the risk of pneumothorax in patients diagnosed with COVID-19, the development of pneumothorax represents a significant prognostic factor in patients who do not receive mechanical ventilation support.[36] In the our study, all patients who developed pneumothorax were receiving respiratory support. Additionally, Ulutas et al.[21] observed elevated levels of CRP, lactate dehydrogenase, ferritin, D-dimer, and interleukin-6 in the majority of patients who developed spontaneous pneumothorax. This finding is consistent with recently published studies examining potential mechanisms of lung injury induced by SARS-CoV-2.[39,40] Cytokine storms are postulated to be involved in the pathophysiology of the disease. However, it remains unclear whether there is a distinction between these inflammatory markers in patients with and without pneumothorax within the context of the broader patient group diagnosed with COVID-19. In our study, the levels of inflammatory markers (WBC, neutrophils, CRP, and D-dimer) were statistically significantly higher in the patient group with pneumothorax compared to the group without pneumothorax. Although protective ventilation strategies are employed in our ICUs, it is premature to draw any definitive conclusions. However, given that our patient cohort comprises critically ill individuals in the ICU, we advise caution with regard to the potential for pneumothorax in patients with a severe inflammatory process who are receiving respiratory support.

Limitations

The present study has some limitations. Firstly, it should be noted that this cohort study population is a specifically selected cohort of ICU patients, and that the number of patients is relatively small. Consequently, the sample is not

representative of all patients with COVID-19. Secondly, this was a retrospective cohort study, which precluded the possibility of conducting a therapeutic analysis within the cohort and of including all variables that influence mortality, given the limitations of the data. Moreover, the retrospective design of the study may have constrained its capacity to discern clinical predictors. Third, no histopathologic evidence of disease was obtained in patients who died. Fourth, the data available for analysis were limited to those collected during the ICU follow-up period, and the post-ICU ward follow-up data were not included in the study.

CONCLUSION

In conclusion, pneumothorax represents a common and potentially fatal complication affecting mortality in patients with COVID-19 pneumonia in the ICU, despite the implementation of protective ventilation strategies. It is of particular importance to ensure that patients who are receiving respiratory support and who are exhibiting a severe inflammatory response are diagnosed and treated promptly. It is imperative that the necessary precautions be taken to prevent contamination during the course of treatment. It should be noted that pneumomediastinum may also be observed in patients with pneumothorax. Although our study is limited by its retrospective nature, the reported findings are important for reducing the incidence of pneumothorax and mortality, as well as improving the prognosis in the ICU, given the high prevalence of infectious diseases in the current era. Due to the limited study population, prospective studies examining the association of viral infections with pneumothorax in a larger population of patients in ICUs are needed.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was approved by the Clinical Researches Ethics Committee of Yıldırım Beyazıt University Yenimahalle Training and Research Hospital (Date: 13/09/2023, Decision No: E-2023-43).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Lai CC, Shih TP, Ko WC, Tang HJ, Hsueh PR. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): the epidemic and the challenges. *Int J Antimicrob Agents*. 2020;55(3):1-9. doi:10.1016/j.ijantimicag.2020.105924
2. Parpucu ÜM, Turan S, Dal HC, et al. Which factors are predicting the mortality in patients with COVID-19 in the intensive care unit? *J Med Palliat Care*. 2021;4(4):368-372. doi:10.47582/jompac.1333211
3. Uysal E, Seğmen F, Ulubaşoğlu P, Zengin EN, Erdem D. The progress of chronic renal disease patients followed by the diagnosis of COVID-19 in ICU. *J Health Sci Med*. 2022;5(5):1443-1448. doi:10.32322/jhsm.1152051
4. Sağlam E, Savaş A, Öke D, Özlü C, Koçar B, Erkalp K. Intensive care unit: mortality score in early prediction of mortality in critical COVID-19 patients. *J Med Palliat Care*. 2023;4(5):572-578. doi:10.47582/jompac.1346978
5. Organization WH. WHO global research and innovation forum to mobilize international action in response to the novel coronavirus (2019-nCoV) emergency. WHO. Accessed 11-12 Feb 2020, 2020. https://www.who.int/news-room/events/detail/2020/02/11/default-calendar/global-research-and-innovation-forum-to-mobilize-international-action-in-response-to-the-novel-coronavirus-(2019-ncov)-emergency
6. Ai T, Yang Z, Hou H, et al. Correlation of chest CT and RT-PCR testing for coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. *Radiology*. 2020;296(2):32-40. doi:10.1148/radiol.2020200642
7. Carotti M, Salaffi F, Sarzi-Puttini P, et al. Chest CT features of coronavirus disease 2019 (COVID-19) pneumonia: key points for radiologists. *Radiol Med*. 2020;125(7):636-646. doi:10.1007/s11547-020-01237-4
8. Kwee TC, Kwee RM. Chest CT in COVID-19: what the radiologist needs to know. *Radiographics*. 2020;40(7):1848-1865. doi:10.1148/rg.219015
9. Caruso D, Polidori T, Guido G, et al. Typical and atypical COVID-19 computed tomography findings. *World J Clin Cases*. 2020;8(15):3177-3187. doi:10.12998/wjcc.v8.i15.3177
10. Kommoss FKF, Schwab C, Tavernar L, et al. The pathology of severe COVID-19-related lung damage. *Dtsch Arztebl Int*. 2020;117(29-30):500-506. doi:10.3238/arztebl.2020.0500
11. Joynt GM, Antonio GE, Lam P, et al. Late-stage adult respiratory distress syndrome caused by severe acute respiratory syndrome: abnormal findings at thin-section CT. *Radiology*. 2004;230(2):339-346. doi:10.1148/radiol.2303030894
12. Liu K, Zeng Y, Xie P, et al. COVID-19 with cystic features on computed tomography: a case report. *Medicine*. 2020;99(18):1-3. doi:10.1097/MD.0000000000020175
13. Sun R, Liu H, Wang X. Mediastinal emphysema, giant bulla, and pneumothorax developed during the course of COVID-19 pneumonia. *Korean J Radiol*. 2020;21(5):541-544. doi:10.3348/kjr.2020.0180
14. Manna S, Maron SZ, Cedillo MA, et al. Spontaneous subcutaneous emphysema and pneumomediastinum in non-intubated patients with COVID-19. *Clin Imaging*. 2020;67:207-213. doi:10.1016/j.clinimag.2020.08.013
15. MacDuff A, Arnold A, Harvey J. Management of spontaneous pneumothorax: British Thoracic Society Pleural Disease Guideline 2010. *Thorax*. 2010;65(2):18-31. doi:10.1136/thx.2010.136986
16. Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet*. 2020;395(10223):507-513. doi:10.1016/S0140-6736(20)30211-7
17. Jamous F, Meyer N, Buus D, et al. Critical illness due to COVID-19: a description of the surge in a single center in sioux falls. *S D Med*. 2020;73(7):312-317.
18. Yao W, Wang T, Jiang B, et al. Emergency tracheal intubation in 202 patients with COVID-19 in Wuhan, China: lessons learnt and international expert recommendations. *Br J Anaesth*. 2020;125(1):28-37. doi:10.1016/j.bja.2020.03.026
19. Yang F, Shi S, Zhu J, Shi J, Dai K, Chen X. Analysis of 92 deceased patients with COVID-19. *J Med Virol*. 2020;92(11):2511-2515. doi:10.1002/jmv.25891
20. Angeles C, Magharious P, Cvetkovic D, Weigel T. The answer to the silent "super spreader": an innovative way to manage chest drains on coronavirus patients with active air leaks. *A A Pract*. 2021;15(3):1-3. doi:10.1213/XAA.0000000000001419

21. Ulutas H, Celik MR, Gulcek I, et al. Management of spontaneous pneumothorax in patients with COVID-19. *Interact Cardiovasc Thorac Surg*. 2022;34(6):1002-1010. doi:10.1093/icvts/ivab280
22. Das KM, Lee EY, Al Jawder SE, et al. Acute middle east respiratory syndrome coronavirus: temporal lung changes observed on the chest radiographs of 55 patients. *AJR Am J Roentgenol*. 2015;205(3):267-274. doi:10.2214/AJR.15.14445
23. Wang XH, Duan J, Han X, et al. High incidence and mortality of pneumothorax in critically Ill patients with COVID-19. *Heart Lung*. 2021;50(1):37-43. doi:10.1016/j.hrtlng.2020.10.002
24. Park SJ, Park JY, Jung J, Park SY. Clinical manifestations of spontaneous pneumomediastinum. *Korean J Thorac Cardiovasc Surg*. 2016;49(4):287-291. doi:10.5090/kjtcs.2016.49.4.287
25. Desai SR. Acute respiratory distress syndrome: imaging of the injured lung. *Clin Radiol*. 2002;57(1):8-17. doi:10.1053/crad.2001.0889
26. Barton LM, Duval EJ, Stroberg E, Ghosh S, Mukhopadhyay S. COVID-19 autopsies, Oklahoma, USA. *Am J Clin Pathol*. 2020;153(6):725-733. doi:10.1093/ajcp/aqaa070
27. Wichmann D. Autopsy findings and venous thromboembolism in patients with COVID-19. *Ann Intern Med*. 2020;173(12):1. doi:10.7326/L20-1206
28. Sihoe AD, Wong RH, Lee AT, et al. Severe acute respiratory syndrome complicated by spontaneous pneumothorax. *Chest*. 2004;125(6):2345-2351. doi:10.1378/chest.125.6.2345
29. Briel M, Meade M, Mercat A, et al. Higher vs lower positive end-expiratory pressure in patients with acute lung injury and acute respiratory distress syndrome: systematic review and meta-analysis. *Jama*. 2010;303(9):865-873. doi:10.1001/jama.2010.218
30. Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med*. 2020;8(5):475-481. doi:10.1016/S2213-2600(20)30079-5
31. Quincho-Lopez A, Quincho-Lopez DL, Hurtado-Medina FD. Case report: pneumothorax and pneumomediastinum as uncommon complications of COVID-19 pneumonia-literature review. *Am J Trop Med Hyg*. 2020;103(3):1170-1176. doi:10.4269/ajtmh.20-0815
32. Sahn SA, Heffner JE. Spontaneous pneumothorax. *N Engl J Med*. 2000;342(12):868-874. doi:10.1056/NEJM200003233421207
33. Sahni S, Verma S, Grullon J, Esquire A, Patel P, Talwar A. Spontaneous pneumomediastinum: time for consensus. *N Am J Med Sci*. 2013;5(8):460-464. doi:10.4103/1947-2714.117296
34. López Vega JM, Parra Gordo ML, Diez Tascón A, Ossaba Vélez S. Pneumomediastinum and spontaneous pneumothorax as an extrapulmonary complication of COVID-19 disease. *Emerg Radiol*. 2020;27(6):727-730. doi:10.1007/s10140-020-01806-0
35. Pieracci FM, Burlew CC, Spain D, et al. Tube thoracostomy during the COVID-19 pandemic: guidance and recommendations from the AAST acute care surgery and critical care committees. *Trauma Surg Acute Care Open*. 2020;5(1):1-4. doi:10.1136/tsaco-2020-000498
36. Ershadi R, Rafieian S, Salehi M, et al. COVID-19 and spontaneous pneumothorax: a survival analysis. *J Cardiothorac Surg*. 2023;18(1):1-9. doi:10.1186/s13019-023-02331-0
37. Satici C, Demirkol MA, Sargin Altunok E, et al. Performance of pneumonia severity index and CURB-65 in predicting 30-day mortality in patients with COVID-19. *Int J Infect Dis*. 2020;98:84-89. doi:10.1016/j.ijid.2020.06.038
38. Aiolfi A, Biraghi T, Montisci A, et al. Management of persistent pneumothorax with thoracoscopy and bleb resection in COVID-19 patients. *Ann Thorac Surg*. 2020;110(5):413-415. doi:10.1016/j.athoracsur.2020.04.011
39. Qin C, Zhou L, Hu Z, et al. Dysregulation of immune response in patients with coronavirus 2019 (COVID-19) in Wuhan, China. *Clin Infect Dis*. 2020;71(15):762-768. doi:10.1093/cid/ciaa248
40. Ye Q, Wang B, Mao J. The pathogenesis and treatment of the `Cytokine Storm' in COVID-19. *J Infect*. 2020;80(6):607-613. doi:10.1016/j.jinf.2020.03.037